PUMP JET WITH AN EXHAUST BYPASS AND ASSOCIATED METHODS

Related Application

[0001] This application is based upon prior filed copending provisional application Serial No. 60/446,138 filed February 10, 2003, the entire disclosure of which is incorporated herein by reference.

Field of the Invention

[0002] The present invention relates to the field of marine outboard motors, and more particularly, to a pump jet for a marine outboard motor.

Background of the Invention

[0003] In a conventional marine outboard motor, a propeller is driven by a drive output of the motor to propel a boat through the water. Most large outboard motors of this type inject the exhaust under water to reduce engine noise and increase propulsive thrust. The exhaust generated by the motor flows downwardly through an exhaust channel and exits the motor through the propeller. This type of motor is referred to as an exhaust-through-the-hub (ETH) motor.

[0004] When the drive output rotates the propeller for forward motion, the exhaust is discharged downstream of the propeller. In contrast, when the

drive output rotates the propeller for reverse motion, the exhaust is discharged such that it can be entrained into the propeller. Even though the exhaust intrudes into the water stream being moved by the propeller in reverse motion, a high reverse thrust level is possible since the propeller is not surrounded by a housing.

[0005] Another type of conventional outboard motor has a pump jet driven by the drive output. In a pump jet, an impeller or rotor is mounted directly to the drive output in place of the propeller, and a ducted housing surrounds the rotor. Modifications to the gear case, cooling or sealing components of the motor are typically not required for a pump jet. Benefits of a pump jet include reducing hazards to swimmers in the vicinity of the motor, protecting the rotor from interference with and damage by foreign objects in the water, and improving the efficiency and performance of the motor. Another benefit inherent with a pump jet is a greater steering response based upon a directed jet of water resulting therefrom.

[0006] As with a propeller, when the drive output rotates the rotor for forward motion, the exhaust is discharged downstream of the rotor. Unfortunately, in reverse motion, the exhaust may enter the water stream within the housing and little or no reverse level thrust is achieved. The Applicants provided one approach to this problem, as disclosed in U.S. Patent No. 5,325,662.

[0007] In the '662 patent, exhaust from a power unit **11** flows downwardly through an exhaust channel **12** and through the rotor hub **55** into an exhaust plenum **44**, as illustrated in FIG. 1. At least one hollow stator vane **50a** extends radially from the exhaust plenum **44**, and

the exhaust is discharged through the stator vane. Since the exhaust is radially discharged outwardly through an exhaust port **64** in the wall of a stator housing **28**, the exhaust will not enter the water stream when the pump jet **40** is in reverse motion.

[0008] Due to the practical need to discharge large volumes of exhaust at wide open throttle, a plurality of hollow stator vanes **50a, 50b** are required. The pump jet area blockage associated with a plurality of stator vanes **50a, 50b** directly competes with the available internal water flow area required by the pump jet **40** to produce acceptable thrust levels. Exhaust systems relying on radial exhaust discharge through hollow stator vanes are difficult to design and fabricate with acceptable propulsive performance.

Summary of the Invention

[0009] In view of the foregoing background, it is therefore an object of the present invention to provide a pump jet for a marine outboard motor that provides high thrust levels in both forward and reverse motions without restricting the water flow therethrough.

[0010] This and other objects, advantages and features in accordance with the present invention are provided by a marine outboard motor comprising a power unit comprising a drive output and an exhaust outlet, and a pump jet comprising a rotor hub and a rotor carried thereby. The rotor hub may be connected to the drive output of the power unit for selective rotation for forward or reverse motion, and the rotor hub may have an internal passageway connected in fluid communication with the exhaust outlet.

[0011] The pump jet may further comprise an exhaust bypass movable between normal and bypassed positions. The exhaust bypass when in the normal position directs exhaust through the internal passageway of the rotor hub to discharge downstream of the rotor during forward motion, and the exhaust bypass when in the bypassed position bypasses exhaust from the internal passageway to discharge downstream of the rotor during reverse motion. Since the exhaust is discharged downstream of the rotor in reverse motion, the pump jet in accordance with the present invention advantageously provides efficient reverse engine performance that is not deteriorated with the intrusion of unwanted exhaust.

[0012] The pump jet in accordance with the present invention has the benefits of combining the advantages of an axial flow marine pump jet with a high performance exhaust-thru-the-hub outboard motor assembly, without compromising forward, neutral and reverse engine performance. These benefits are achieved by the use of a centerbody central exhaust discharge with an exhaust bypass. The pump jet thus provides the capability to discharge large volumes of engine exhaust over a broad range of engine rotational speeds (rpm) without compromising the passage design for streamlined water flow through its interior and around its exterior. This assures that a high propulsive efficiency pump jet can be developed for large horsepower motors.

[0013] The exhaust bypass is preferably self-set to the normal position based upon rotation of the rotor hub for forward motion, and to the bypassed position based upon rotation of the rotor hub for reverse motion. The exhaust bypass may comprise an outer

sleeve having a plurality of spaced apart exhaust windows therethrough, and an inner sleeve having a plurality of spaced apart exhaust windows therethrough. The exhaust bypass is in the normal position when the spaced apart exhaust windows are non-overlapping, and is in the bypassed position when the exhaust windows are overlapping.

[0014] The outer sleeve may be stationary and the inner sleeve may rotate for placing the exhaust bypass in the normal or bypassed position. The outer sleeve may further include at least one slot, and the inner sleeve may comprise at least one pin extending outwardly therefrom and into the at least one slot. The exhaust bypass is in the normal or bypassed position based upon rotation of the at least one pin in the at least one slot.

[0015] The drive output comprises a rotor shaft extending outwardly from the power unit and through the exhaust bypass for engaging the rotor hub. In one embodiment of the rotor hub and the exhaust bypass, the rotor hub includes an outer end surface with a circular groove therein, and the inner sleeve includes a circularly shaped protruding end that is received by the groove in the rotor hub. Rotation of the rotor hub causes the inner sleeve to rotate based upon a viscous friction therebetween.

[0016] In another embodiment of the rotor hub and the exhaust bypass, the rotor hub further comprises a lever pivotally connected in the internal passageway thereof and has a first end for engaging the inner sleeve, and rotation of the rotor hub causes the inner sleeve to rotate. The lever also has a second end so that rotation of the rotor hub above a predetermined

speed causes the first end to disengage the inner sleeve. The lever may be under compression so that the first end thereof engages the inner sleeve.

[0017] The pump jet may further comprise a rotor housing surrounding the rotor hub, the rotor and the exhaust bypass. A stator housing may be connected to the rotor housing and may comprise a stator hub having an internal passageway connected in fluid communication with the internal passageway of the rotor hub. The marine outboard motor may further comprise a housing for carrying the power unit, and the housing may include a mounting plate (i.e., an anti-cavitation plate) extending above the pump jet. The stator housing may further comprise a dorsal fin extending therefrom for securing the pump jet to the mounting plate. Since the stator housing typically has a larger surface area than the rotor housing, attachment of the pump jet to the mounting plate via the dorsal fin on the stator housing provides a significantly larger structural load path for absorbing the loads generated by high horsepower pump jets. Previous attachment methods utilized the rotor housing, which was restricted in size because of the smaller surface area available with respect to the size of the rotor housing.

[0018] Nonetheless, the rotor housing may also comprise a dorsal fin extending therefrom for securing the pump jet to the mounting plate. This may be in addition to the dorsal fin on the stator housing. In addition, the marine outboard motor further comprises a skeg, and a clamp for securing the rotor housing to the skeg.

[0019] Another aspect of the present invention is directed to a method for discharging exhaust from a

pump jet for a marine outboard motor as described above. The method comprises placing the exhaust bypass in the normal position during forward motion for directing exhaust through the internal passageway of the rotor hub for discharging downstream of the rotor, and placing the exhaust bypass in the bypassed position during reverse motion for bypassing exhaust from the internal passageway for discharging downstream of the rotor during reverse motion.

Brief Description of the Drawings

[0020] FIG. 1 is a partial cross-sectional view of a marine outboard motor in which exhaust is discharged through at least one stator vane in the pump jet in accordance with the prior art;

[0021] FIG. 2 is a perspective view of a rotor hub and a rotor carried thereby in accordance with the present invention.

[0022] FIG. 3 is a partial cross-sectional view of a pump-jet in accordance with the present invention in which exhaust is being discharged downstream of the rotor in forward boat motion;

[0023] FIG. 4 is a partial cross-sectional view of a pump-jet in accordance with the present invention in which exhaust is being discharged downstream of the rotor in reverse boat motion;

[0024] FIG. 5a is a side view of the exhaust bypass in accordance with the present invention;

[0025] FIGS. 5b and 5c are respective side views of the inner sleeve and the outer sleeve of the exhaust bypass in accordance with the present invention;

[0026] FIGS. 6a and 6b are respective end views of the exhaust bypass in the normal position and in the

bypassed position in accordance with the present invention;

[0027] FIG. 7 is an enlarged, partial cross-sectional view of another embodiment of the rotor hub and exhaust bypass in accordance with the present invention;

[0028] FIGS. 8a and 8b are respective perspective views of the exhaust bypass as shown in FIG. 7 in the normal position and in the bypassed position.

Detailed Description of the Preferred Embodiments

[0029] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout, and prime notation is used to indicate similar elements in alternative embodiments.

[0030] A pump jet for a marine outboard motor in accordance with the present invention will now be discussed. Example marine outboard motors are manufactured by Evinrude and Johnson Motors (Bombardier Recreational Products Incorporated) and Mercury Marine, Inc. (a subsidiary of Brunswick Corporation). In alternative embodiments, an inboard motor could be substituted for the outboard motor, as readily appreciated by those skilled in the art. For purposes

of illustrating the present invention, discussion will be directed toward a marine outboard motor.

[0031] Referring again to FIG. 1, a conventional marine outboard motor **10** with a pump jet **40** comprises a power unit **11** including a drive output **22** and an exhaust outlet **13**. The drive output **22** is a propeller shaft extending from a gear case **15** that is part of the power unit **11**. In the pump jet **40**, an impeller or rotor **16** is mounted (e.g., spline fitted) directly on the propeller shaft **22** in place of a propeller. The gear case **15** places the rotor **16** in forward or reverse motion, or in a neutral position. A rotor housing **78** and a stator housing **28** surrounds the rotor **16**.

[0032] The pump jet **140** in accordance with the present invention will now be discussed with reference to FIGS. 2-4. The pump jet **140** comprises a rotor hub **155** and a rotor **116** carried thereby, as illustrated in FIG. 2. The rotor hub **155** is connected to the drive output **122** for selective rotation for forward or reverse motion. The rotor hub **155** has an internal passageway **121** connected in fluid communication with the exhaust outlet **113**. In one embodiment, the internal passageway **121** is a segmented annulus within the rotor hub **155**, as shown in FIG. 2.

[0033] The pump jet **140** further comprises an exhaust bypass **130** that is movable between normal and bypassed positions. The exhaust bypass **130** is positioned between the gear case **115** and the rotor hub **155**. In particular, the drive output **122** from the gear case **115** extends through the exhaust bypass **130** and into the rotor hub **155**.

[0034] When the exhaust bypass **130** is in the normal position, exhaust is directed through the internal

passageway **121** of the rotor hub **155** for discharging downstream of the rotor **116** during forward motion, as illustrated in FIG. 3. When the exhaust bypass **130** is in the bypassed position, exhaust is bypassed from the internal passageway **121** for discharging downstream of the rotor **116** during reverse motion, as illustrated in FIG. 4.

[0035] As will now be discussed in greater detail, the exhaust bypass **130** as illustrated in FIG. 5a is self-set or self-actuated to the normal position based upon rotation of the rotor hub **155** for forward motion, and to the bypassed position based upon rotation of the rotor hub for reverse motion. In other words, the exhaust bypass **130** does not require any external control linkage connected thereto to be placed in the normal or bypassed positions.

[0036] The exhaust bypass **130** comprises an inner sleeve **134** having a plurality of spaced apart exhaust windows **144** therethrough, and an outer sleeve **132** also having a plurality of spaced apart exhaust windows **142** therethrough, as respectively illustrated in FIGS. 5b and 5c. Both of the inner and outer sleeves **132, 134** are cylindrical in shape, and an outer surface of the exhaust bypass **130** (i.e., the outer sleeve **132**) is substantially aligned with an outer surface of the rotor hub **155**. The exhaust bypass **130** is in the normal position when the spaced apart exhaust windows **142, 144** are non-overlapping (FIG. 6a), and is in the bypassed position when the exhaust windows are overlapping (FIG. 6b).

[0037] The inner and outer sleeves **132, 134** may be constructed from steel, aluminum or plastic, for example. Moreover, the inner and outer sleeves **132,**

134 may be made from different materials. For example, the outer sleeve **132** may be heat-treated aluminum or stainless steel, whereas the inner sleeve **134** may be an aluminum casting or a molded plastic part. However, other materials may be used as readily appreciated by those skilled in the art.

[0038] In the illustrated embodiment of the exhaust bypass **130**, the outer sleeve **132** is stationary and the inner sleeve **134** rotates for placing the exhaust bypass in the normal or bypassed position. The outer sleeve **132** includes an extension **133** that is connected to the gear case **115** adjacent the drive output **122.** The outer sleeve **132** is also connected to the rotor housing **178** via a plurality of rotor housing hub struts **180**, as illustrated in FIGS. 3 and 4.

[0039] The outer sleeve **132** further includes at least one slot **145** having spaced apart ends. In the illustrated embodiment, there are a plurality of spaced apart slots **145** along an edge of the outer sleeve **132**. The length **x** of each slot **145** is approximately equal to width **y** of the exhaust windows **142, 144.**

[0040] The inner sleeve **134** comprises at least one stop pin **147** extending outwardly therefrom and into the at least one slot **145**. In the illustrated embodiment, there are a plurality of spaced apart stop pins **147** corresponding to the plurality of slots **145**. The width of each slot **145** is slightly larger than a diameter of each stop pin **147**. The stop pins **147** may be spring pins pressed into predrilled hole locations, as readily appreciated by those skilled in the art.

[0041] When the stop pins **147** are inserted into their respective slots **145**, the inner sleeve **134** is located axially relative the outer sleeve **132**. The

length **x** of the slots **145** in the circumferential direction limits the circumferential rotation of the inner sleeve **134** relative to the fixed outer sleeve **132** to a small angle between the normal position and the bypassed position of the exhaust bypass **130**. The angle may be within 5 to 15 degrees, for example.

[0042] As discussed above, the exhaust bypass **130** is self-set or self-actuated to the normal position based upon rotation of the rotor hub **155** for forward motion, and to the bypassed position based upon rotation of the rotor hub for reverse motion. In one embodiment, this is accomplished as a result of the hydrodynamic forces generated by rotation of the rotor hub **155**, which is transferred to the inner sleeve **134** via viscous friction therebetween.

[0043] More particularly, the inner sleeve **134** includes a protruding edge or lip **149**, and the rotor hub **155** has a corresponding groove **159** (FIG. 2) machined therein for receiving the protruding edge during assembly. For a 50 to 75 horsepower outboard motor, the protruding edge **149** protrudes about a half inch to provide positive opening and closing forces. Rotation of the rotor hub **155** thus causes the inner sleeve **134** to rotate based upon the viscous friction therebetween. A corresponding depth of the groove **159** is about 1/16 to 1/8 inch to insure that the groove can rotate at full operational speed without damaging the protruding edge **149** from the inner sleeve **134**.

[0044] When the rotor hub **155** is rotating so that the boat is moving in a forward motion, the viscous friction between the protruding edge **149** and the groove **159** causes the inner sleeve **134** to rotate until the stop pins **147** rest against a first end of a

corresponding slot **145**. Rotation of the inner sleeve **134** in the forward motion causes the exhaust windows **144** thereof to be non-overlapping with the exhaust windows **142** in the outer sleeve **132**, as best shown in FIG. 6a.

[0045] This is the normal position of the bypass exhaust **130** so that exhaust is directed through the internal passageway **121** of the rotor hub **155**. The exhaust from the internal passageway **121** of the rotor hub **155** is further directed through another passageway or plenum **161** extending through a stator housing **168** connected to the rotor housing **178**. The passageway **161** of the stator housing **168** is in fluid communication with the passageway **121** through the rotor hub **155**. In effect, the passageway **161** through the stator housing **168** serves as an exhaust tailpipe for the pump jet **140** in forward motion.

[0046] Likewise, when the rotor hub **155** is rotating so that the boat is moving in a reverse motion, the viscous friction between the protruding edge **149** and the groove **159** causes the inner sleeve **134** to rotate until the stop pins **147** rest against a second end of a corresponding slot **145**. Rotation of the inner sleeve **134** in the reverse motion causes the exhaust windows **144** thereof to be overlapping with the exhaust windows **142** in the outer sleeve **132**, as best shown in FIG. 6b.

[0047] This is the bypassed position of the bypass exhaust **130** so that exhaust is directed from the exhaust outlet **113** through the exhaust windows **142, 144** instead of through the internal passageway **121** of the rotor hub **155**. Elevated water pressure in the passageway **161** through the stator housing **168** is created by the reverse motion, and this causes the

exhaust to discharge through the exhaust windows **142, 144** so that the water flow direction and the exhaust flow direction out of the pump jet **140** are the same in the reverse motion. Consequently, the exhaust is prevented from intruding into the pump jet water stream and a high reverse thrust level is possible.

[0048] The exhaust windows **142, 144** in the inner and outer sleeves **132, 134** are preferably sized so that they exceed the exhaust-through-the-hub rotor area by at least a factor of 1.5 to insure that the exhaust flow easily passes through the exhaust windows. As noted above, the length **x** of the slots **145** controls the time to go from the normal position of the exhaust bypass **130** to the bypassed position, and the length is preferably selected to minimize or reduce the time for unacceptable exhaust blow-by to occur at low to mid-range motor operations. As also noted above, the length **x** also determines the angle through which the inner sleeve **134** rotates.

[0049] Another embodiment of the rotor hub **155'** and the exhaust bypass **130'** will now be discussed with reference to FIGS. 7, 8a and 8b. An inner surface of the exhaust bypass **130'** is substantially aligned with the internal passageway **121'** of the rotor hub **155'**. The rotor hub **155'** further comprises a lever **200'** pivotally connected in the internal passageway **121'**. The lever **200'** is used to rotate the inner sleeve **132'** to the normal or bypassed position. The lever **200'** has a first end **202'** forceably engaging the inner surface of the inner sleeve **134'**.

[0050] When the rotor hub **155'** rotates in the forward or reverse motion, the inner sleeve **134'** rotates until the pins **147'** contact the first or second

ends of the slots **145'**. The lever **200'** also has a weighted second end **204'** causing the first end to disengage the inner surface of the inner sleeve based upon rotation of the rotor hub **155'** exceeding a predetermined speed.

[0051] The lever **200'** is a see-saw type actuator arrangement. The outer sleeve **132'** is thin walled and is the rigid portion of the bypass exhaust **130'**, and is attached to the stationary rotor housing **178'** to prevent movement. The inner sleeve **134'** is thick walled and is constrained, but is free to rotate within the outer sleeve **132'** within an angle defined by the length **x'** of the slots **145'**.

[0052] Both the outer and inner sleeves **132', 134'** include exhaust windows **142', 144'** extending therethrough. The exhaust windows **142', 144'** are not limited to any particular orientation or shape as long as they are non-overlapping or not aligned with respect to one another when the exhaust bypass **130'** is in the normal position for forward motion, and they are overlapping or aligned with respect to one another when the exhaust bypass is in the bypassed position for reverse motion. Of course, the exhaust windows **142', 144'** are preferably sized so that they exceed the exhaust-through-the-hub rotor area by at least a factor of 1.5 to insure that the exhaust flow easily passes through the exhaust windows.

[0053] As illustrated in FIG. 7, the see-saw lever **200'** is a canted lever that is attached to the rotor hub **155'** using a suitable pin **210'** causing the lever to rotate with the rotor **116'** about an axis of the drive output. The lever **200'** is also permitted to pivot about the attachment pin **210'**. The second end **204'** of

the lever **200'** includes a counter-weight that is a distance **L1'** from the attachment pin **210'**. The first end **202'** of the lever **200'** is a friction surface end that is a distance **L2'** from the attachment pin **210'**.

[0054] A normal resting position of the lever **200'** is shown in FIG. 7 when the outboard motor is in neutral or at low operating speeds. In the resting position, the friction surface end **202'** is in contact with the inner surface of the inner sleeve **134'**, either naturally or by a suitably installed spring device.

[0055] When the engine gear selector places the gear case **115'** in reverse, the inner sleeve **134'** rotates counter-clockwise by the lever **200'** that is attached to the rotor **116'**, thereby placing the exhaust bypass **130'** in the bypassed position, i.e., the exhaust windows **142'**, **144'** are overlapping. As the reverse engine speed increases, the rotational inertial force acting through the centroid of the counter-weighted forces on the second end **204'** forces the lever **200'** to move away from the inner sleeve **134'** through an angle α based upon the length **x** of the slots **145'**, thereby disengaging the first end **202'** of the lever **200'** from the inner sleeve **134'**. This position is shown by the dashed outline of the lever **220'** in FIG. 7.

[0056] After reverse motion is completed, the engine is placed in neutral, thereby diminishing the rotation inertial forces and allows the friction surface of the first end **202'** to come in contact with the inner surface of the inner sleeve **134'**. When the forward gear is selected, the inner sleeve **134'** is rotated clockwise by the friction surface of the lever **200'**, thereby placing the exhaust bypass **130'** in a normal position. As the forward engine speed increases, the

rotational inertial force acting through the second end **204'** forces the lever **200'** to move away from the inner sleeve **134'**, thereby disengaging the first end **202'** from the inner sleeve **134'**.

[0057] Referring back to FIGS. 3 and 4, the rotor housing **178** encloses the rotor hub **155**, the rotor **116** and the exhaust bypass **121**. The stator housing **168** is connected to the rotor housing **178** and includes a stator hub **165** having an internal passageway **161** connected in fluid communication with the internal passageway **121** of the rotor hub **155**.

[0058] The marine outboard motor has an anticavitation plate **190** used by the pump jet **140** to attach thereto. The stator housing **168** comprises a dorsal fin **207** extending therefrom for securing the pump jet **140** to the anticavitation plate **190**. The rotor housing **178** also comprises a dorsal fin **209** extending therefrom for securing the pump jet **140** to the anticavitation plate **190**. The marine outboard motor also comprises a skeg **210**, and a clamp **212** for securing the rotor housing **178** to the skeg.

[0059] The rotor housing **178** is positioned on the engine gearcase **115** by an alignment sleeve (not shown) that assists in locating the rotor **116** concentrically within the rotor housing. The rotor **116** is installed within the rotor housing **178**, onto the propeller shaft **122** via the normal arrangement for a conventional propeller. Correct rotor **116** rotation is provided by the concentric alignment achieved between the rotor housing **155** and the gearcase alignment sleeve, which is rigidly attached to the gearcase hub body.

[0060] The stator housing **168**, containing an integral dorsal fin **207** at the 12:00 position, is

rigidly attached to the anti-ventilation plate **190** by bolts with adjustable positioning capability for proper alignment between the stator housing **168**, the propeller shaft **122**, and the rotor housing **178**. The pump jet **140** becomes an integral assembly by securing the stator housing **168** to the rotor housing **178** with a family of attachment screws uniformly distributed around the perimeter of the stator housing interface boundary with the rotor housing.

[0061] Since the stator housing **168** typically has a larger surface area than the rotor housing **178**, attachment of the pump jet **140** to the mounting plate **190** via the dorsal fin **207** on the stator housing provides a significantly larger structural load path for absorbing the loads generated by high horsepower pump jets. Previous attachment methods utilized the rotor housing **178**, which was restricted in size because of the smaller surface area available with respect to the size of the rotor housing.

[0062] Another aspect of the present invention is directed to a method for discharging exhaust from a pump jet for a marine outboard motor as described above. The method comprises placing the exhaust bypass **130, 130'** in the normal position during forward motion for directing exhaust through the internal passageway **121, 121'** of the rotor hub **155, 155'** for discharging downstream of the rotor, and placing the exhaust bypass in the bypassed position during reverse motion for bypassing exhaust from the internal passageway for discharging downstream of the rotor during reverse motion.

[0063] Many modifications and other embodiments of the invention will come to the mind of one skilled in

the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is understood that the invention is not to be limited to the specific embodiments disclosed, and that modifications and embodiments are intended to be included within the scope of the appended claims.